MAP GQ-1661

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE TSE BONITA SCHOOL QUADRANGLE, McKINLEY COUNTY, NEW MEXICO

By Robert S. Zech

NEW YORK
JUN 19 1989
STATE LIBRARY

GEOLOGIC QUADRANGLE MAP
Published by the U.S. Geological Survey, 1989

ZECH—GEOLOGY, TSE BONITA SCHOOL QUAD., NEW MEXICO 1:24,000 MAP GQ-1661

best copy available

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC QUADRANGLE MAP
TSE BONITA SCHOOL QUADRANGLE, NEW MEXICO
GQ-1661

CORRELATION OF MAP UNITS

Qar, Qal, Qoa	Qf, Qc, Qt	Qfs	Holocene
			Holocene and Pleistocene(?) — QUATERNARY
Kmfa, Kmfc, Kmfg, Kgl, Kcg, Kcb, Kcda, Kmm			Upper Cretaceous — CRETACEOUS
Kcdb, Kgl, Kcdb, Kg, Kgl, Km, Kmj, Kml, Kmb, Kdt, Kmw, Kd			Upper Cretaceous — CRETACEOUS
Jmw, Jmb, Jmj, Jmr			Upper Jurassic — JURASSIC

DESCRIPTION OF MAP UNITS

[Descriptions of units shown only on schematic section derived from outcrop and drill-hole data in adjacent quadrangles (Thaden, in press; Zech, in press; Kirk and Zech, 1987a)]

Qar **Arroyo deposits (Holocene)**—Pale-yellowish-brown to grayish-orange weathering alluvium deposited in arroyos since the inception of the most recent cycle of arroyo cutting (circa 1850) (Bryan, 1954)

Ql **Lacustrine deposits (Holocene)**—Sand and silt deposited as lake beds in natural and artificial lakes; during dry periods material is reworked by eolian processes

Qf **Alluvial-fan deposits (Holocene)**—Pale-yellowish-brown to grayish-orange weathering, unconsolidated alluvium deposited on valley floors as alluvial fans; during dry periods, material partly reworked by eolian processes. Superposed fans mapped separately with no attempt to distinguish depositional sequence

Qls **Landslide deposits and slump blocks (Holocene)**

Qal **Alluvial deposits (Holocene and Pleistocene?)**—Pale-yellowish-brown to grayish-orange weathering unconsolidated sand, silt, and gravel deposited in graded stream valleys on flood plains prior to the inception of the most recent cycle of arroyo cutting (circa 1850) (Bryan, 1954)

Qc **Colluvium (Holocene and Pleistocene?)**—Intermixed, unconsolidated, talus and sand, silt, and gravel slope-wash deposits that become finer grained downslope and grade into alluvial deposits (Qal); mapped only in a...ns where forms significant and continuous cover that obscures underlying bedrock

Qt **Talus deposits (Holocene and Pleistocene?)**—Large, unconsolidated, angular rock fragments which accumulate locally at the base of cliffs and cover the underlying bedrock

Qoa **Older alluvial deposits (Holocene and Pleistocene?)**—Pale-yellow-brown to gray and pale-reddish-brown weathering, unconsolidated to poorly consolidated sand, silt, and gravel deposits which are remnants of dissected alluvial fans(?), older alluvial surfaces(?), and older eolian deposits(?), topographically higher than alluvial deposits (Qar, Qal)

Menefee Formation (Upper Cretaceous—Campanian Age)—As revised by Peterson and Kirk (1977)

Kmfa **Allison Member**—A variable interbedded sequence of predominantly yellowish gray and dusky yellow to olive gray weathering shale and minor siltstone; very pale orange to pale-yellowish-brown, very fine to medium-grained, moderately well to poorly sorted, crossbedded, calcareous, lenticular sandstone; very minor carbonaceous shale; and a few lenticular subbituminous coal beds less than 35 cm (14 in.) thick. Upper portion of the member was removed by erosion. Lower contact gradational; interfingers with Cleary Coal Member of the Menefee (Kmfc) and the combined Cleary Coal Member and Gibson Coal Member of the Crevasse Canyon Formation (Kmfg). Distinguished from the Cleary Coal Member by the absence of coal beds more than 35 cm (14 in.) thick; this distinction follows the usage of Sears (1925) who subdivided coal-bearing units on the basis of presence or absence of mineable coal. The contact between the Cleary and Allison Members is approximately located because it commonly changes stratigraphic position with the changing character and distribution of coal beds; it is however, useful in separating the coal-bearing part from the relatively barren part of the formation. Upper part of member eroded; remaining thickness as much as 247 m (815 ft)

Kmfc **Cleary Coal Member**—Shown on schematic diagram only. A variable interbedded sequence of predominantly yellowish gray to medium-bluish-gray shale and siltstone; lenticular very fine to medium-grained, poorly sorted very pale orange and moderate-orange-pink sandstone; dark-gray carbonaceous shale; lenticular subbituminous coal beds (most less than 35 cm (14 in.) thick but some as thick as 1.9 m (6.2 ft)) and thin dark-gray and brown iron-rich concretionary beds. Interfingers with the underlying Point Lookout Sandstone (Kpl). Mapped with the Gibson Coal Member of the Crevasse Canyon Formation as an undivided unit (Kmfg) southwest of the depositional pinchout of the Point Lookout Sandstone. As a separate unit the Cleary Coal Member may occur in the subsurface in the extreme northeast corner of the quadrangle. Thickness 79–81 m (260–266 ft)

Kmfg **Cleary Coal Member of the Menefee Formation and Gibson Coal Member of the Crevasse Canyon Formation undivided (Upper Cretaceous)**—A variable interbedded sequence of predominantly yellowish gray to medium-bluish-gray shale and siltstone which locally weathers light to silvery gray; lenticular, very fine to medium-grained, poorly sorted, very pale orange and moderate-orange-pink sandstone; dark-gray carbonaceous shale; subbituminous coal beds and thin, dark-gray and brown, iron-rich concretionary beds. Some coal beds have burned at the outcrop altering overlying rocks to form clinker beds or zones. The Cleary Coal Member of the Menefee Formation is mapped with the Gibson Coal Member of the Crevasse Canyon Formation as a combined unit southwest of the pinchout of the Point Lookout Sandstone because they have similar lithology and lateral stratigraphic continuity representing essentially continuous deposition. Follows precedent set by Sears and others (1941, p. 114) and O'Sullivan and others (1972, p. 45) for delineation of geologic contacts; member names are in accord with the revised nomenclature of Mesaverde Group outlined by Beaumont and others (1956). Estimated thickness of the combined members 75–122 m (246–400 ft)

Kpl **Point Lookout Sandstone (Upper Cretaceous—Campanian and Santonian Age)**—Shown on schematic diagram only. Yellowish-gray to very pale orange very fine to fine-grained, well-sorted calcareous sandstone. Represents what was mapped to the east as the Point Lookout Sandstone and Hosta Tongue of the Point Lookout Sandstone which are inseparable in the absence of the Satan Tongue of the Mancos Shale; coincides with mapping to the east (Robertson, 1986; Kirk and Sullivan, 1987; Kirk and Zech, 1987a, b). May occur in subsurface in the extreme northeast corner of quadrangle. Estimated thickness 0–10 m (0–33 ft)

Crevasse Canyon Formation (Upper Cretaceous)—As revised by Beaumont and others (1956)

Kcg **Gibson Coal Member (Santonian Age)**—Shown on schematic diagram only. Interbedded light- to dark-gray shale and siltstone, lenticular, very fine to medium-grained very pale orange to orange-pink crossbedded sandstone; minor dark-gray carbonaceous shale; thin lenticular subbituminous coals (most less than 35 cm (14 in.) thick, some as thick as 3.8 m (12.4 ft)), and thin, iron-rich, concretionary beds. Interfingers with the underlying Bartlett Barren Member (Kcb). Mapped with the Cleary Coal Member as an undivided unit (Kmfg) southwest of the depositional pinchout of the Point Lookout Sandstone (Kpl). Thickness 69–87 m (226–285 ft)

Kcb **Bartlett Barren Member (Santonian Age)**—Interbedded sequence of predominantly yellowish gray and dusky yellow to grayish-olive weathering shale and siltstone; lenticular, very pale orange to pale-yellowish-brown and white, very fine to medium-grained, moderately well to poorly sorted, lenticular, crossbedded, calcareous sandstone; very minor amounts of carbonaceous shale and subbituminous coal beds which are less than 35 cm (14 in.) thick. Thickness 54–96 m (177–315 ft)

Kcda **Dalton Sandstone Member (Santonian Age)**—Shown on schematic diagram only. Yellowish-gray to very pale orange, very fine to fine-grained, well-sorted, calcareous sandstone. The Dalton pinches out to the southeast between the Bartlett Barren Member (Kcb) and the Dilco Coal Member (Kcdi). Member may be present in the subsurface in northeast corner of quadrangle

Kcdi **Dilco Coal Member (Coniacian Age)**—Interbedded light- to dark-gray and variegated shale and siltstone; very fine to medium-grained, moderately well to poorly sorted, white to very pale orange lenticular sandstone (fluvial channel deposits); very fine to fine-grained, well-sorted, white to very pale orange laterally continuous thin sandstone (overbank deposits); minor carbonaceous shale, and lenticular subbituminous coal beds. Most coal beds less than 35 cm (14 in.) thick; some beds as thick as 112 cm (3.7 ft). One 3.7 m (12 ft) thick, medium- to coarse-grained fluvial(?) sandstone bed present along the upper contact at the northern border of the quadrangle (35°45'; 108°57'), bed pinches out approximately 0.6 km (0.4 mi) to the south. Lower part interbedded with the Tornillo Member of the Gallup Sandstone (Kgt). Thickness 58–91 m (190–299 ft)

Mancos Shale (Upper Cretaceous)

Kmm **Mulatto Tongue (Santonian Age)**—Shown on schematic diagram only. Light-gray to dark-yellowish-brown fissile shale and mudstone, with thin interbeds of very pale orange to brown, fine-grained, well-sorted calcareous sandstone. May be present in subsurface in extreme northeast corner of quadrangle

Km **Main body (Campanian to Turonian Age)**—Light- to dark-gray fissile shale with minor amounts of interbedded siltstone and some scattered thin, discontinuous limestone and calcareous sandstone beds. Lower contact not exposed in this quadrangle

Kmj **Juana Lopez Member (Turonian Age)**—Shown on schematic diagram only. Interbedded thin, fossiliferous limestone, fine-grained calcareous sandstone, and dark-gray, fissile shale. Member makes a distinctive marker zone on geophysical logs

Kml **Lower part (Coniacian, Turonian and Cenomanian Age)**—Shown on schematic diagram only. Light- to dark-gray fissile shale with minor amounts of interbedded siltstone, scattered thin discontinuous limestone beds, calcareous sandstone beds, and thin bentonite beds

Kmb **Bridge Creek Limestone Member (Turonian Age)**—Shown on schematic diagram only. Interbedded thin, fossiliferous limestone and dark-gray fissile shale. Distinctive marker zone on geophysical logs. Changed from Greenhorn Limestone Member to Bridge Creek Limestone Member by Hook and Cobban (1981)

Kmw **Whitewater Arroyo Tongue (Cenomanian Age)**—Shown on schematic diagram only. Yellowish-brown to yellowish-gray fissile shale; locally contains beds of light-brown sandy siltstone and limestone

Gallup Sandstone (Upper Cretaceous)—For further discussion of see Sears, 1925; Sears and others, 1941; and O'Sullivan and others, 1972; Molenaar, 1973; Kirk and others, 1978

Kgh **Torrivio Member (Coniacian Age) (Molenaar, 1973)**—White to very pale orange and locally grayish pink, poorly sorted, fine- to medium-grained, feldspathic, lenticular, fluvial sandstone with scattered coarse grains and some granule-sized grains; locally conglomeratic. Occurs as several beds interbedded with the Dilco Coal Member of the Crevasse Canyon Formation (Kcdi). Single beds as thick as 26 m (85 ft)

Kg **Main body (Coniacian and Turonian Age)**—Grayish-pink to very pale orange, very fine to fine-grained, well-sorted, calcareous regressive marine sandstone. Upper contact sharp. Lower contact gradational, interfingers with main body of the Mancos Shale (Km). Thickness 16–26 m (52–85 ft)

Kgl **Lower sandstone bed (Coniacian and Turonian Age)**—Grayish-pink to very pale orange, very fine to fine-grained, well-sorted, calcareous sandstone. Bed rises stratigraphically, and merges with main body of the Gallup Sandstone (Kg) in northwest corner of quadrangle. Upper contact sharp. Lower contact gradational, interfingers with the main body of the Mancos Shale (Km). Thickness 14–24 m (45–78 ft)

Dakota Sandstone (Upper Cretaceous—Cenomanian Age)

Kdt **Twowells Tongue**—Shown on schematic diagram only. Yellowish-brown to tan, very fine to medium-grained, well-sorted, calcareous sandstone. Locally contains oyster beds (*Gryphaea newberryi* and *Exogyra* sp.). To the west, the Twowells Tongue is present but pinches out in the northern part of the Window Rock quadrangle (Thaden, in press). Thickness unknown

Kd **Main body**—Shown on schematic diagram only. Upper part, light-gray to tan, fine- to medium-grained, moderately well sorted, silica cemented, quartzose sandstone; lower part, interbedded light- to dark-gray carbonaceous shale, light-gray to white and tan coarse-grained poorly sorted sandstone, lenticular coal, and conglomerate. Thickness unknown

Morrison Formation (Upper Jurassic)

Jmb **Brushy Basin Member**—Shown on schematic diagram only. Green and grayish-green, locally mottled red and purple claystone; with thin dark-green fine-grained well-sorted siliceous sheet sandstone and white fine- to medium-grained lenticular crossbedded sandstone. Thickness unknown

Jmw **Westwater Canyon Member**—Shown on schematic diagram only. Very pale orange and light-gray to pink, fine- to coarse-grained, locally conglomeratic, poorly sorted, subangular to subrounded, feldspathic sandstone and arkose. Thickness unknown

Jmj **Unnamed sandstone**—Shown on schematic diagram only. Yellowish-gray to white fine- to medium-grained well-sorted, crossbedded eolian sandstone. Formerly mapped as Cow Springs Sandstone, Zuni Sandstone, and Bluff Sandstone. Regional correlations uncertain. Thickness unknown

Jmr **Recapture Member**—Shown on schematic diagram only. Reddish-brown clayey siltstone (locally mottled green, gray, and purple) and reddish-brown very fine grained sandstone, interbedded with some white and light-gray very fine to medium-grained well-sorted lenticular crossbedded sandstone. Thickness unknown

Contact—Dashed where approximately located, dotted where concealed

Fault, showing dip—Dashed where approximately located, dotted where concealed. D, downthrown side; U, upthrown side; T, throw measured in feet

Strike and dip of beds

Strike of vertical joints

Direction of flow in fluvial paleochannels

Earth dam or dike

Adit

Coal bed—Thickness where measured in centimeters

Monoclinal fold—Showing upper and lower fold axes. Arrows indicate direction of dip

Clinker beds

Strip mine

DISCUSSION

STRUCTURE

The Tse Bonita School quadrangle is located approximately 24 km (15 mi) northwest of Gallup, New Mexico. The quadrangle lies on the western side of the Gallup sag, a large structural embayment or synclinorium on the southern edge of the San Juan Basin. The Gallup sag is bounded by the Nutria monocline on the east and the Defiance monocline on the west. The Defiance monocline, a large structural feature that forms the western edge of the San Juan Basin from Lupton, Arizona to the Four Corners area, influences the structure of the quadrangle. Steeply dipping, older rocks crop out along the west-central edge and near northwest corner of the quadrangle.

The Burned Death monocline, a smaller monocline in the Gallup sag, crosses the northeast corner and extends south along the border of the quadrangle into the Twin Lakes quadrangle to the east. The monocline has approximately 305 m (1,000 ft) of structural relief and both upper and lower axes can be seen in canyon walls. Approximately 6.4 km (4 mi) north of the quadrangle the Burned Death monocline merges with the Defiance monocline.

Only a few small normal faults with relatively small displacements occur in the quadrangle. These faults are probably intraformational, formed from differential compaction and dewatering soon after deposition of the host rock. Steep northeast-trending faults having displacements less than 30 m (100 ft) and blocks upthrown to the southeast have been reported along Tse Bonita Wash and along the unnamed wash east of and parallel to Coal Mine Wash in the McKinley mine (Wilson, 1977). However, these faults are covered by stream alluvium or by mine reclamation and are not shown on the map.

The channel sandstones, splay sandstones, and fine-grained overbank deposits that make up the Menefee Formation and Gibson Coal Member of the Crevasse Canyon Formation, which cover much of the quadrangle, commonly have nonparallel upper and lower bounding surfaces and have undergone small-scale intraformational deformation. This produces subtle strike and dip inconsistencies and make reliable surface structural measurements almost impossible to obtain in areas of low structural relief. Additional subsurface control is necessary before cross sections can be constructed and structure contours drawn.

GEOMORPHOLOGY

A drainage divide crosses the quadrangle from northwest to southeast and surface water in the northeast corner of the quadrangle drains north to the Chaco and San Juan Rivers; surface water in the rest of the quadrangle drains south to the Puerco River. Ground water from the whole quadrangle probably follows the structure of the north-plunging Gallup sag and drains north into the San Juan Basin.

The surface water drainage divide has migrated south and west as a result of the ability of the northern Chaco-San Juan River drainage system to maintain and extend its valleys at a lower level than the Puerco River drainage system. Valleys in the northeast part of the quadrangle, which have been extended by headward erosion, are high in relief, steep, V-shaped in cross section, and devoid of alluvium and colluvium. Evidence suggests that the southern Puerco River drainage system is older than the Chaco-San Juan River drainage system because of its more mature low topographic relief and abundant deposits of colluvium and alluvium. The alluvium and colluvium accumulations in the southern drainage system may be in part due to a loss of tributaries to the northern drainage system and subsequent aggradation.

Siltrite(?)-cemented fluvial-channel sandstones of the Menefee Formation and the Gibson and Dilco Coal Members of the Crevasse Canyon Formation are the most erosion-resistant lithologies in the quadrangle. Trough crossbeds are well preserved in the channel sandstones and indicate a paleoflow in a north to northeast direction. These narrow elongate sandstone bodies commonly form sandstone caps for many of the small ridges and are probably responsible for the dominant north to northeast alignment of many small ridges and intervening valleys in areas not controlled by monoclinal structure. The thalweg-like drainage pattern of larger streams, such as Tse Bonita Wash and Coal Mine Wash, is probably influenced by a combination of structure, faults (Wilson, 1977), and the erosion-resistant distributary sandstones.

ECONOMIC GEOLOGY

The coal resources of the McKinley mine are primarily in the combined Cleary Coal Member of the Menefee Formation and the Gibson Coal Member of the Crevasse Canyon Formation in the Tse Bonita School quadrangle. Wilson (1977) has projected production of the McKinley mine to be 4,000,000 to 5,000,000 ton per year with a life expectancy of 30–37 years. Seven economic coal beds have been identified in the mine. Named from bottom to top, the coal beds are the green, brown, blue, fuchsia, yellow, and orange beds (Wilson, 1977), a lower split-off of the blue coal bed was later identified and named the red coal bed. The fuchsia coal bed is the thickest and the most extensive strippable coal in the mine. The Btu content of the coal in the mine ranges from 9,500 to 10,000 Btu with 10–12 percent ash, 13–15 percent moisture, and 0.5–0.7 percent sulfur.

Deposits of competent gravels, uncommon in this part of the San Juan Basin, do not occur in the quadrangle. However, there are many places in the Gibson and Cleary Members where coal has burned and the resulting clinker deposits are used locally for road aggregate. Two small active coal seam burns were found near the head of Deer Springs Wash and Black Springs Wash, respectively.

REFERENCES

Beaumont, E.C., Dane, C.H., and Sears, J.D., 1956, Revised nomenclature of the Mesaverde Group in the San Juan Basin, New Mexico: American Association of Petroleum Geologists Bulletin, v. 40, no. 9, p. 2149–2162

Bryan, Kirk, 1954, The geology of Chaco Canyon, New Mexico: Smithsonian Miscellaneous Collections, v. 122, no. 7, 65 p.

Hook, S.C., and Cobban, W.A., 1981, Late Greenhorn (mid-Cretaceous) discontinuity surfaces, southwest New Mexico, *in* Hook, S.C., compiler, Contributions to mid-Cretaceous stratigraphy of New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 180, 35 p.

Kirk, A.R., Huffman, A.C., Jr., Zech, R.S., Robertson, J.F., and Jackson, T.J., 1978, Review of the history of usage of the Gallup Sandstone and related units, southern and western San Juan Basin, New Mexico: U.S. Geological Survey Open-File Report 78–1055, 51 p.

Kirk, A.R., and Sullivan, M.W., 1987, Geologic map of the Dalton Pass quadrangle, McKinley County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ–1593, scale 1:24 000

Kirk, A.R., and Zech, R.S., 1984, Geologic map of the Oak Spring quadrangle, McKinley County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ–1585, scale 1:24 000

———1987a, Geologic and structure contour maps of the Big Rock Hill quadrangle, McKinley County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map, GQ–1594, scale 1:24 000

———1987b, Geologic map of the Hard-Ground Flats quadrangle McKinley County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ–1592, scale 1:24 000

Molenaar, C.M., 1973, Sedimentary facies and correlation of the Gallup Sandstone and associated Upper Cretaceous formations, northwestern New Mexico, *in* Fassett, J.E., ed., Cretaceous and Tertiary rocks of the Southern Colorado Plateau: Four Corners Geological Society, Memoir, p. 96–110

O'Sullivan, R.B., Repenning, C.A., Beaumont, E.C., and Page, H.G., 1972, Stratigraphy of the Cretaceous rocks and the Tertiary Ojo Alamo Sandstone, Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: U.S. Geological Survey, Professional Paper 521–F, 66 p.

Peterson, Fred, and Kirk, A.R., 1977, Correlation of the Cretaceous rocks in the San Juan Basin, Black Mesa Basin, north, and Hevers Basin, southern Colorado Plateau, *in* Fassett, J.E., ed., New Mexico Geological Society Guidebook 28th Annual Field Conference, San Juan Basin, p. 167–178

Robertson, J.F., 1986, Geologic map of the Crownpoint quadrangle, McKinley County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ–1596, scale 1:24 000

Sears, J.D., 1925, Geology and coal resources of the Gallup-Zuni Basin, New Mexico: U.S. Geological Survey Bulletin 767, 53 p.

Sears, J.D., Hunt, C.B., and Hendricks, T.A., 1941, Transgressive and regressive Cretaceous deposits in southern San Juan Basin, New Mexico: U.S. Geological Survey, Professional Paper 193–F, p. 101–121

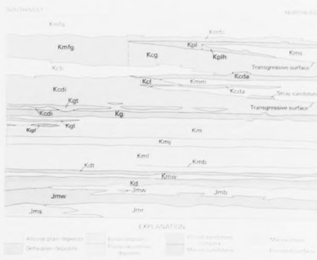
Thaden, R.E., in press, Geologic map of the Window Rock quadrangle, Apache County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ–1647, scale 1:24 000

Wilson, J.F., 1977, The McKinley mine, *in* Fassett, J.E., ed., Guidebook of San Juan Basin, New Mexico, Geological 28th Annual Field Conference, San Juan Basin: p. 253–255

Zech, R.S., 1982, Paleobathymetries in the Upper Cretaceous Point Lookout Sandstone, Southern San Juan Basin, New Mexico: U.S. Geological Survey Open-File Report 82–1(F), 32 p.

Zech, R.S., in press, Geologic map of the Twin Lakes quadrangle, McKinley County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ–1659, scale 1:24 000

INDEX SHOWING LOCATION OF TSE BONITA SCHOOL QUADRANGLE (SHADED) AND OTHER U.S. GEOLOGICAL SURVEY GEOLOGIC QUADRANGLE MAPS (GQ) AND OPEN-FILE REPORTS (OF)



SCHEMATIC DIAGRAM SHOWING REGIONAL STRATIGRAPHIC RELATIONSHIPS OF MAPPED AND SUBSURFACE UNITS AND THEIR DEPOSITIONAL ENVIRONMENTS. The Satan Tongue of Mancos Shale (Kms), Hosta Tongue of Point Lookout Sandstone (Kph), the unnamed tongue of Crevasse Canyon Formation (Kcl), and the "stray sandstone" of Sears and others (1941) as shown above are not present in this quadrangle. All other symbols are explained in the Description of Map Units. Not all stratigraphic relationships shown are present in this quadrangle.

GEOLOGIC MAP OF THE TSE BONITA SCHOOL QUADRANGLE, McKINLEY COUNTY, NEW MEXICO

By
Robert S. Zech

1989

best copy available

GEOLOGIC MAP SYMBOLS

COMMONLY USED ON MAPS OF THE UNITED STATES GEOLOGICAL SURVEY

(Special symbols are shown in explanation)

Contact – Dashed where approximately located; short dashed where inferred; dotted where concealed

Contact – Showing dip; well exposed at triangle

Fault – Dashed where approximately located; short dashed where inferred; dotted where concealed

Fault, showing dip – Ball and bar on downthrown side

Normal fault – Hachured on downthrown side

Fault - Showing relative horizontal movement

Thrust fault – Sawteeth on upper plate

Anticline – Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric anticline – Short arrow indicates steeper limb

Overturned anticline – Showing direction of dip of limbs

Syncline – Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric syncline – Short arrow indicates steeper limb

Overturned syncline – Showing direction of dip of limbs

Monocline – Showing direction of plunge of axis

Minor anticline – Showing plunge of axis

Minor syncline – Showing plunge of axis

Strike and dip of beds – Ball indicates top of beds known from sedimentary structures

Inclined ⊕ Horizontal

Vertical Overturned

Strike and dip of foliation

Inclined Vertical Horizontal

Strike and dip of cleavage

Inclined Vertical Horizontal

Bearing and plunge of lineation

Inclined Vertical Horizontal

Strike and dip of joints

Inclined Vertical Horizontal

Note: planar symbols (strike and dip of beds, foliation or schistosity, and cleavage) may be combined with linear symbols to record data observed at same locality by superimposed symbols at point of observation. Coexisting planar symbols are shown intersecting at point of observation.

Shafts

Vertical Inclined

Adit, tunnel, or slope

Accessible Inaccessible

Prospect

Quarry

Active Abandoned

Gravel pit

Active Abandoned

Oil well

Drilling Shut-in Dry hole abandoned

Gas Show of gas

Oil Show of oil

best copy available